

REMARKS

In the Office Action dated November 9, 2009, the Examiner rejects claims 1-25 under 35 U.S.C. § 103(a). With this Amendment, claims 1-5, 7-11 and 14-18, 21, 23 and 24 are amended. No claims are added or canceled. After entry of this Amendment, claims 1-25 are pending in the Application. Reconsideration of the Application as amended is respectfully requested.

Response to rejections based on Kato et al. in view of Serizawa et al.

The Examiner rejects independent claim 1 and its dependent claims 3-6 and 20, independent claim 7 and its dependent claims 9-12 and 22, independent claim 13, and independent claim 14 and its dependent claims 16-19 under 35 U.S.C. §103(a) as being unpatentable over Kato et al. (US 6,082,482) in view of Serizawa et al. (US 5,347,458).

The Examiner states that Kato et al. teaches all of the features of the independent claims except for a summation formula that uses a steering angle, steering velocity and steering acceleration terms. The Examiner states that Serizawa et al. shows such a summation equation using gains M0, M1 and M2 for steering angle, velocity and acceleration. The Examiner states that it would have been obvious to one skilled in the art at the time the invention was made to include such a summation in Kato et al. because the reaction force is supposed to replicate the feeling of a mechanically coupled steering wheel, and steering velocity and acceleration effect the feeling of steering a mechanically coupled steering wheel. The Examiner further states that since steering angle velocity and acceleration are used in Kato's hands off state embodiment of FIG. 7, it would be obvious to use these terms in the hand-on state as well to simplify the formula, such as in the embodiment of FIG. 10. (Office Action, pp. 6, 8-11 and 13).

Applicants first submit that the Examiner has mischaracterized the teachings of Kato et al. in several material aspects. In response to the Applicants' previous remarks with respect to this same rejection, the Examiner states that "[i]t is clear from the figures that many coefficients and gains (T, I, K, P, D, H, V, J) vary based on whether the hand-off state is detected." (Office Action, p. 3). Applicants submit that many of these variables cannot be characterized as coefficients and/or gains. Regardless, however, Applicants submit that no

coefficients or gains in any of the terms that result in S24, S50 and S68 vary based on detection of either the hands-on or hands-free state. That is, any coefficients or gains are not conditional with respect to the hands-on or hands-free state—they depend only on operating conditions without regard to the hands-on or hands-free state.

Applicants further dispute the Examiner's statement that the terms in the summations of S24, S40 (*sic*: S50) and S68 are based on steering angle, velocity and acceleration terms. (Office Action, p. 2). Each of the embodiments uses different combinations of terms to calculate a reaction force motor target voltage. In each of the three embodiments described, the motor target voltage V_M in the hands-on state follows this equation: $V_M = V_O + D'n + P'n$ where V_O is the previous target voltage. (FIG. 5, S50). Stated simply, FIG. 5 selects a reaction force instruction torque T_M from a table based on the actual steering operating angle. (Col. 8, ll. 1-8). Then, a deviation ΔDn between the reaction force instruction torque T_M and a detected torque T_S is calculated. The deviation is used to calculate PI (integral and proportional) elements Dn , Pn added together to calculate a reaction force motor target current J_M . (FIG. 5, S34-S40). The deviation between the motor target current J_M and the detected motor current J_S is calculated. The deviation is used to calculate PI (integral and proportional) elements $D'n$, $P'n$. (FIG. 5, S44-S50). FIG. 5 teaches to one skilled in the art that none of a steering angle term $Kp*\theta$, a steering angle velocity term $Kd*d\theta/dt$ and a steering angle acceleration term $Kdd*d^2\theta/dt^2$ should be considered when operating in a hands-on state. The Examiner states that FIG. 5 uses a steering angle. (Office Action, pp. 3, 5, 7-8, 10 and 12). This, however, is not the claimed feature, which describes a steering angle term $Kp*\theta$. FIG. 5 uses a measured steering angle of the steering wheel for comparison with a table of values to obtain a reaction force instruction torque T_M . Further, the measured steering angle is not multiplied by K_{I2} as stated by the Examiner. (Office Action, p. 3). Instead, a difference between the reaction force instruction torque T_M and measured torque is multiplied by predetermined integral constant K_{I2} . (Col. 8, ll. 10-14). The Examiner acknowledges that Kato et al. does not disclose a steering angle velocity term $Kd*d\theta/dt$ and a steering angle acceleration term $Kdd*d^2\theta/dt^2$ in the hands-on state but alleges that coefficients for these terms can be considered to be set to zero when the hands free state

is not detected. (Office Action, pp. 3-6, 8, 10 and 12-13). Applicants submit that the Examiner completely fails to cite any portion of Kato et al. for such a teaching or suggestion.

In the first embodiment of FIG. 4, when in the hands free state, the target voltage $V_M = V_O + I_n + P_n$ where V_O is the previous target voltage. (FIG. 4, S24, S26). Basically, FIG. 4 teaches calculating a deviation ΔI_n between a target and a measured steering angle. The target steering angle is obtained from the rack shaft position. (Col. 7, ll. 42-47). The deviation ΔI_n is used to calculate PI (integral and proportional) elements I_n , P_n (FIG. 4, S18-S22). There is no steering angle velocity term $K_d * d\theta/dt$ and no steering angle acceleration term $K_{dd} * d^2\theta/dt^2$ in FIG. 4. Notably, the Examiner does not argue that these terms are in FIG. 4.

In the second embodiment of FIG. 7, when in the hands free state, the target voltage $V_M = V_O + H_n + P_n$ where V_O is the previous target voltage. (FIG. 7, S68, S72). Basically, FIG. 7 teaches calculating a deviation ΔH_n between a target and a measured steering angular speed. The target steering angular speed is obtained from the vehicle speed and the angle of the steered wheels. (Col. 9, ll. 32-39). The deviation ΔH_n is used to calculate PI (integral and proportional) elements H_n , P_n (FIG. 4, S62-S66). There is no steering angle term $K_p * \theta$ and no steering angle acceleration term $K_{dd} * d^2\theta/dt^2$ in FIG. 7. The Examiner argues that FIG. 7 teaches these features because it uses a steering angle and because proportional element of step S66 is “in effect” a steering acceleration term because it takes a difference in steering velocity between two cycles, which would be a change in steering velocity with respect to time. (Office Action, pp. 3, 5, 7-8, 10 and 12). Applicants dispute both these positions. Kato et al. describes calculating a target steering operating angular speed of the steering wheel based on the angle of the steered wheels and the moving speed of the vehicle. (Col. 9, ll. 32-39). The steering angle of the steering wheel is not used in this determination, and the feature of a steering angle term $K_p * \theta$ as one of a plurality of terms as claimed is not shown or described. With respect to step 66, the proportional element is not a steering angle acceleration term $K_{dd} * d^2\theta/dt^2$ as known to those skilled in the art. That is, $d\theta_{Mn}/dt - d\theta_{Mn-1}/dt$ is not equal to $d^2\theta_M/dt^2$, and $d\theta_{Sn}/dt - d\theta_{Sn-1}/dt$ is not equal to $d^2\theta_S/dt^2$. Instead, P_n merely incorporates errors in angular velocity between one cycle and a previous cycle.

In the third embodiment of FIG. 10, when in the hands free state, the target voltage $V_M = V_O + D'n + P'n$ where V_O is the previous target voltage. (Col. 11, ll. 9-11). This is the same formula as in the hands on state of FIG. 5. (Id.) The difference is that when the hands free state is detected, the steered angle of the wheels is used to obtain a lower reactor force instruction torque T_M to use in the calculations of FIG. 5. (Col. 11, ll. 3-11). The steering angle of the steering wheel is not used. (Id.) As described above, FIG. 5 uses none of a steering angle term $Kp*\theta$, a steering angle velocity term $Kd*d\theta/dt$ and a steering angle acceleration term $Kdd*d^2\theta/dt^2$.

Collectively, Kato et al. teaches to one skilled in the art that in the state where the driver's hands are on a steering wheel in a steer-by-wire system (e.g. the normal state), reaction force is controlled by controlling the motor target voltage V_M as shown in FIG. 5 such that $V_M = V_O + D'n + P'n$ where V_O is the previous target voltage. This formula is generally based on a deviation between a measured motor current and a target motor target current, which is in turn based on a deviation of the reaction force instruction torque as indicated by the driver's driving wheel steering angle and the detected steering torque. Kato et al. further teaches to one skilled in the art that reaction force should be controlled by different methods when a hands free state is detected. One of these different methods of controlling is using completely different formulas to calculate the motor target voltage V_M than that shown in FIG. 5. This is exemplified by FIG. 4, where $V_M = V_O + I_n + P_n$ is based on a deviation between a target steering angle (based on rack shaft position) and a detected steering angle, and FIG. 7, where $V_M = V_O + H_n + P_n$ is based on a deviation between a target steering angular speed (based on an angle of the steered wheels and the vehicle speed) and a calculated steering angular speed of the steering wheel. Another of these different methods of controlling is using the same formula to calculate the motor target voltage V_M as that shown in FIG. 5 (namely, $V_M = V_O + D'n + P'n$), but to use a completely different angle to obtain a reaction force instruction torque T_M as the starting point. Namely, the steered angle of the vehicle wheels is used to obtain reaction force instruction torque T_M in FIG. 10 instead of a steering angle of the steering wheel as in FIG. 5.

None of the embodiments teaches or suggests that V_M is equal to a summation of a plurality of terms, the plurality of terms including at least a steering angle term $Kp*\theta$, a

steering angle velocity term $K_d \cdot d\theta/dt$ and a steering angle acceleration term $K_{dd} \cdot d^2\theta/dt^2$; wherein θ is a steering angle of the steering wheel, K_p is a steering angle gain, K_d is a steering angle velocity gain, and K_{dd} is a steering angle acceleration gain.

Moreover, Kato et al. fails to teach or suggest a controller configured to reduce the steering reaction force applied if the hands-off state is indicated relative to the steering reaction force applied if the hands-on state is indicated by using a value of at least one of a coefficient and a gain for at least one of the plurality of terms in the summation if the hands-off state is indicated that is different from a value used if the hands-on state is indicated. Each of FIGS. 4 and 7 use completely different formulas with completely different terms that those in FIG. 5. No coefficient or gain of a common term changes. In FIG. 10, the same formula as in FIG. 5 is used, and no coefficient or gain of any term changes. The only change is to the input instruction torque T_M , which change is not based on a coefficient or gain change of a common term, but is instead based on a different measured variable (angle of steered wheels versus angle of steering wheel).

In response to Applicants' previous amendments, the Examiner points to the statement in Kato et al. that the reaction force is reduced at col. 11, ll. 6-19. The Examiner then acknowledges that the claimed summation is not used by Kato et al., but states that it would be obvious to use all of the terms in one summation and reduce any or all of them in order to reduce the reaction force when hands-off is detected. The Examiner then cites FIG. 4C of Serizawa for a summation equation using gains M_0 , M_1 and M_2 . (Office Action, pp. 2-3). As mentioned above, the Examiner later states that it would have been obvious to one skilled in the art at the time the invention was made to include such a summation in Kato et al. because the reaction force is supposed to replicate the feeling of a mechanically coupled steering wheel, and steering velocity and acceleration effect the feeling of steering a mechanically coupled steering wheel. (Office Action, pp. 6, 9, 11 and 13). Presumably, the Examiner means in place of the formula in FIG. 5 of Kato et al., which includes none of the claimed terms. This conclusion is supported by the Examiner's further statement that since steering angle velocity and acceleration are used in Kato's hands off state embodiment of FIG. 7, it would be obvious to use these terms in the hand-on state as well to simplify the formula, such as in the embodiment of FIG. 10. (Id.)

Applicants respectfully submit that reducing reaction force is expressly described only with reference to the embodiment of FIG. 10. To the extent that the Examiner contends that the completely different calculations designed merely to return the wheel to the neutral position in FIGS. 4 and 7 would also result in a reduction in reaction force, Applicants submit that the Examiner has not provided any support for such a conclusion.

Further, Applicants submit that the rationale offered by the Examiner for making the combination is not supported by the references or by any inherent knowledge to those skilled in the art. The problem identified in the present invention is that known methods of controlling steering reaction force in a hands-on state can result in overshoot when hands are released from the wheel after taking a curve. ([0023]). That is, in a conventional system, the steering wheel restoration force becomes too large when the steering wheel is released (that is, in a hands-off state), so that the steering wheel goes past the neutral position and overshoots. ([0052]-[0053]). This is shown in FIG. 8. The convergence time of state variables from the time of start of the hands-off is substantial. Embodiments of the present invention eliminate this overshoot to more rapidly converge the system behavior. ([0056], [0066], [0070], [0072] and FIG. 10).

This problem is not identified by Kato et al. or Serizawa et al. Serizawa et al. describes only operation in a hands-on state. The problem Kato et al. purportedly addresses is the rapid return of a steering wheel to the neutral position after the driver loosens their hold. (Col. 2, ll. 11-19). This rapid return makes the driver's steering feel different from that of a conventional steering apparatus. (Col. 2, ll. 19-21). In the first and second embodiments (FIGS. 4 and 7), reaction force control (FIG. 5) is ended, and the natural return of the wheel occurs due to self-aligning torque. That is, T_M is not even calculated. (Col. 2, line 35-col. 3, line 21; col. 7, ll. 11-14). In the third embodiment (FIG. 10), reaction force control (FIG. 5) is not ended, but the reaction force instruction torque is changed initially so that the self-aligning torque is realized. (Col. 11, ll. 19-27). Based on the stated problem in Kato et al., the embodiments are designed to slow down the rapid return of the steering wheel to the neutral position. These embodiments do this by relying on the steered portion of the system (driving wheels, rack shaft) for target values in the hands-off state versus the steering portion of the system (steering wheel) as described in the hands-on implementation of FIG. 5. One

skilled in the art would not come to the conclusion that the formula of Serizawa et al. would address this problem because, unlike the teachings in all embodiments of Kato et al. regarding the hands-off state, Serizawa et al. relies on the steering angle of the steering wheel and its first and second derivatives (steering angle speed and steering angle acceleration). Serizawa et al.'s formula is based replicating the feel when in a hands-on state and does not affect the conclusions drawn from Kato et al. that one should look to the steered portion of the system when operating in the hands-off state. Moreover, Serizawa et al. calculates torque, which is not even used in two of the three embodiments of Kato et al.

For all of the foregoing reasons, the combination proposed by the Examiner would not have been obvious to one skilled in the art at the time the invention was made. Thus, each of independent claims 1, 7, 13 and 14 and their dependent claims are allowable over the cited references.

Nonetheless, Applicants have amended each of independent claims 1, 7 and 14 in an attempt to further prosecution. Claim 13 remains unamended. Each of claims 1, 7 and 14 now recites that K_p is a steering angle gain dependent on the steering angle such that the steering angle gain is non-zero when the steering angle is non-zero and dependent on vehicle speed such that an absolute value of the steering angle gain is higher at a first vehicle speed than at a second vehicle speed lower than the first vehicle speed, K_d is a steering angle velocity gain dependent on a steering angle velocity such that the steering angle velocity gain is non-zero when the steering angle velocity is non-zero and dependent on the vehicle speed such that an absolute value of the steering angle velocity gain is higher at the first vehicle speed than at the second vehicle speed, and K_{dd} is a steering angle acceleration gain dependent on a steering angle acceleration such that the steering angle acceleration gain is non-zero when the steering angle acceleration is non-zero and dependent on the vehicle speed such that an absolute value of the steering angle acceleration gain is higher at the first vehicle speed than at the second vehicle speed. Applicants submit that these features are not found in the cited references and provide an additional basis for the allowance of claims 1, 7 and 14 and their dependent claims.

Applicants further submit that the recited combination does not teach the additional features of dependent claims 3, 9 and 16. The Examiner states that these features are taught because Kato et al. teaches using a different gain/coefficient for steering angle in the hands-off state versus the hands-on state. (Office Action, p. 14). This is not a correct statement of the teachings of Kato et al. as previously described with respect to the independent claims above. More importantly, the recited combination does not teach a steering angle coefficient A that is based on a steering torque. Applicants have, however amended these claims in an attempt to further prosecution. Namely, each of these claims now expressly refines the steering angle term to comprise $A \cdot K_p \cdot \theta$. Neither cited reference teaches or suggests this feature. For the foregoing reasons, and based on their dependence from allowable independent claims, these claims are allowable over the cited combination.

The Examiner states that Kato et al. disclose steering velocity and acceleration gains in the hands-off state (FIG. 7, velocity gain $KI3$ and acceleration gain $KP3$) and reducing all components of the reaction force in the hands-off state from the reaction force using in the hands-on state (col. 11, ll. 1-10). The Examiner states that Serizawa et al. measures these quantities, and it would have been obvious to one skilled in the art to modify Kato et al. to include using the steering angle velocity and/or steering angle acceleration to calculate the reaction force to replicate the feeling of a mechanically coupled steering wheel. The Examiner further states that it would have been obvious to use with the embodiment of FIG. 10 in Kato et al., where all components of the reaction force are reduced. (Office Action, pp. 14-15). This is the grounds for rejecting claims 4, 5, 10, 11, 17 and 18. Applicants submit first that the Examiner has mischaracterized the teachings of Kato et al. Kato et al. teaches in FIG. 10 reducing the reaction force instruction torque based on the steered angle of steered wheels. Presumably, this is merely a table as in FIG. 5. There are no "components" of reaction force to reduce in Kato et al. Further, $KI3$ and $KP3$ are not velocity and acceleration gains in terms as claimed. The Examiner also does not address the feature of claims 4, 10 and 17 where the steering angle acceleration term includes a steering angle acceleration coefficient C based on steering torque and does not address the feature of claims 5, 11 and 18 where the steering angle velocity term includes a steering angle velocity

coefficient B based on steering torque. These claims have been amended to expressly clarify these terms. Neither cited reference teaches or suggests the claimed coefficients. For the foregoing reasons, and based on their dependence from allowable independent claims, these claims are allowable over the cited combination.

Applicants further submit that the recited combination does not teach the additional features of dependent claims 6, 12 and 19. Applicants admit that steering torque is detected in FIG. 5. The Examiner's rejection states that the controller in Kato et al. is further adapted to vary the reaction force when the indicated steering torque decreases, citing col. 7, ll. 11-14 and col. 11, ll. 3-8. (Office Action, p. 15). The citation to column 7 refers to executing return control instead of reaction force control in the event the hands-off state is detected. The citation to column 11 refers to correcting the reaction force instruction torque based on the angle of the steered wheels. Neither supports the Examiner's position, and the claimed features are not those recited in the rejection. Applicant submits that, to the extent that the values K in Kato et al. could be called either gains or coefficients, they are not described as being based on the steering torque. The coefficients C used in Serizawa et al. to develop the formulas therein are unrelated to steering torque. For the foregoing reasons, and based on their dependence from allowable independent claims, these claims are allowable over the cited combination.

Claim 20 depends from claim 1 and describes the additional features wherein the steering angle term includes a steering angle coefficient A, the steering angle velocity term includes a steering angle velocity coefficient B and the steering angle acceleration term includes a steering angle acceleration coefficient C; and wherein a value for each of the steering angle coefficient A, the steering angle velocity coefficient B and the steering angle acceleration coefficient C depends on steering torque. The Examiner admits that Kato et al. does not teach that such coefficient depend on steering torque, but states that it is sufficient that Kato et al. discloses reducing the reaction force when steering torque decreases because FIG. 3 detects the hands-off state based on steering torque, and the reaction force is reduced based on steering torque. (Office Action, p. 15). The Examiner concludes that it would have

been obvious to reduce any or all coefficients in order to reduce reaction force when steering torque indicates a hands-off state. This is not a feature claimed in claim 20. Applicants submit that the reaction force is not reduced based on steering torque—it is independent of steering torque as clearly seen in FIG. 5. Further, the Examiner's argument is irrelevant to the claimed features. Neither Kato et al. nor Serizawa et al. teaches or suggests, either alone or in combination, coefficients for terms having separate gains. For the foregoing reasons, and based on its dependence from an allowable independent claim, claim 20 is allowable over the cited combination.

Claim 22 depends from 7 and further comprises at least one of a steering angle coefficient A in the steering angle term, a steering angle velocity coefficient B in the steering angle velocity term and a steering angle acceleration coefficient C in the steering angle acceleration term. The Examiner does not expressly discuss this feature in the Office Action. Applicants submit that claim 22 is allowable for the reasons cited with respect to claim 20. Further, claim 22 is allowable based on its dependence from allowable claim 7.

Response to rejections based on Kato et al. in view of Serizawa et al. and Higashira et al.

The Examiner rejects claims 2, 8, 15, 21 and 23-25 under 35 U.S.C. §103(a) as being unpatentable over Kato et al. in view of Serizawa et al. and Higashira et al. (US 5,908,457).

With regard to claims 2, 8 and 15, the Examiner states that Kato et al. considers the road surface in the reaction torque but only applies torque to return to neutral in a hands-off state. The Examiner further states that the steering angle and steering torque signals used to determine reaction force in the hands-on state can be “indicative of a road surface reaction force” because that phrase is broad. Finally, the Examiner states that the coefficients are different in the hands-off state of FIGS. 4, 7 and 10. The Examiner states that Kato et al. does not particularly disclose reducing a road surface reaction torque coefficient or gain. However, the Examiner states that Higarashi et al. teaches a steer by wire system that generates a signal indicative of road surface reaction force and applies a steering reaction force corresponding to the indicated road surface reaction force. The Examiner

concludes that it would have been obvious to include these features in Kato et al. because reaction force is supposed to replicate the feeling of a mechanically coupled steering wheel. Since the purpose of the road surface reaction force is to recreate the feel, it would be obvious to reduce or eliminate in a hands-off state. (Office Action, pp. 15-16). Similar rejections are made against claims 21, 23 and 24.

Applicants first submit that claims 8 and 15 expressly recite that the road surface reaction force is detected, not that a signal “indicative of” the road surface reaction force is detected. Neither claim 23 nor claim 24 uses the phrase “indicative of.” The Examiner states that coefficients are different in the hands-off state of FIGS. 4, 7 and 10. Applicants fail to see what this has to do with any claimed element of these claims. Further, and contrary to the Examiner’s position, Kato et al. does not teach or suggest the feature of claims 4, 8 and 15 wherein the plurality of terms includes a road surface reaction force term $D \cdot K_f \cdot F$ based the road surface reaction force where D is a road surface reaction force coefficient, K_f is a road surface reaction force gain and F is the road surface reaction force. Nor does Higarishi et al. teach or suggest such a term. Kato et al. also does not teach or suggest the feature of claims 21, 23 and 24 wherein the plurality of terms include a road surface reaction force term $K_f \cdot F$ where F is a road surface reaction force and K_f is a road surface reaction force gain. Nor does Higarishi et al. teach or suggest such a term. Applicants further submit that Higarashi et al. does not cure the deficiencies in the rejection of the independent claims as described above based on Kato et al. and Serigawa et al. Accordingly, claims 4, 8, 15, 21, 23 and 24 and dependent claim 25 are allowable over the recited combination for these reasons.

In addition, Applicants have amended claims 4, 8, 15, 21, 23 and 24 to further recite that the road surface reaction force gain is dependent on the road surface reaction force such that the road surface reaction force gain is non-zero when the road surface reaction force is non-zero and dependent on vehicle speed such that an absolute value of the road surface reaction force gain is higher at the first vehicle speed than at the second vehicle speed in an attempt to further prosecution. These additional features are neither taught nor suggested by the cited combination and provide an additional basis for the allowance of these claims and dependent claim 25.

Claim 25 depends from claim 24 and includes the features wherein the steering angle term includes a steering angle coefficient A, the steering angle velocity term includes a steering angle velocity coefficient B, the steering angle acceleration term includes a steering angle acceleration coefficient C and the road surface reaction force term includes a road surface reaction force coefficient D; and wherein a value for each coefficient depends on steering torque. Applicants submit that these features are neither taught nor suggested by the cited combination for the reasons stated with respect to claim 20.

Conclusion

It is submitted that this Amendment has antecedent basis in the Application as originally filed, including the specification, claims and drawings, and that this Amendment does not add any new subject matter to the Application. Consideration of the Application in view of these comments is requested. It is submitted that the Application is in suitable condition for allowance; notice of which is requested.

If the Examiner feels that prosecution of the present application can be expedited by way of an Examiner's amendment, the Examiner is invited to contact the undersigned at the telephone number listed below.

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